CHAPTER 11. NATIONAL IMPACT ANALYSIS

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CHAPTER 11. NATIONAL IMPACT ANALYSIS

11.1 INTRODUCTION

The national impacts analysis evaluates the impact of a proposed standard from a national perspective rather than from the customer perspective represented by the life-cycle cost (LCC) (see Chapter 8 of this TSD). This chapter describes the U.S. Department of Energy (DOE)'s methodology for estimating future national energy savings (NES) from amended energy conservation standards for packaged terminal air conditioners (PTACs) and packaged terminal heat pumps (PTHPs) as well as the national economic impact using the net present value (NPV) metric. DOE determined both the NPV and NES for each trial standard level (TSL) that it considered for all the equipment classes of PTAC and PTHP equipment. DOE considered up to seven TSLs for each equipment class. The detailed discussion on the TSLs can be found in Chapter 9 of this TSD.

For each TSL, DOE calculated the NPV, as well as the NES, as the difference between a base case forecast (without amended standards) and the standards case (with amended standards). The NES refers to cumulative energy savings from 2012 through 2042. The NPV refers to cumulative monetary savings. DOE calculated net monetary savings in each year relative to the base case as the difference between total operating cost savings and increases in total installed cost. Cumulative savings are the sum of the annual NPV over the specified period. DOE accounted for operating cost savings until 2062; that is, until all the equipment installed through 2042 is retired.

Results of the national impact analysis (NIA) described here include: 1) national energy consumption and savings, 2) monetary value of energy savings to the nation as a result of standards, 3) increased total installed costs to the Nation as a result of standards, and 4) the net present value of energy savings (i.e., the difference between the present monetary values of energy savings and increased total installed costs).

To make the analysis more accessible and transparent to all stakeholders, DOE used an MS Excel spreadsheet model to calculate the energy savings and the national economic costs and savings from amended standards. The spreadsheet model is accessible on the Internet at (http://www.eere.energy.gov/buildings/appliance_standards/commercial/packaged_ac_hp.html). Details and instructions for using the spreadsheet are discussed in appendix F. A more detailed set of results is available in appendix G.

Unlike the LCC analysis, the NES spreadsheet does not use distributions for inputs or outputs. DOE examined sensitivities by applying different scenarios. DOE used the NES spreadsheet to perform calculations of energy savings and NPV, using the annual energy consumption and total installed cost data from the LCC analysis. DOE forecasted the energy savings, energy cost savings, equipment costs, and NPV of benefits for each of equipment classes from 2012 through 2042. The forecasts provided annual and cumulative values for all four output parameters as described above.

11.1.1 General Approach

Over time, in the standards case, equipment that is more efficient gradually replaces less efficient equipment. This affects the calculation of both the NES and NPV, both of which are a function of the total number of units in use and their efficiencies, and thus are dependent on annual shipments and equipment lifetime, including changes in shipments and retirement rates in response to changes in equipment costs due to standards. Both calculations start by using the estimate of shipments, and the quantity of units in service, that are derived from the shipments model.

With regard to estimating the NES, because more efficient PTACs and PTHPs gradually replace less efficient ones, the energy per unit of capacity used by the PTACs and PTHPs in service gradually decreases in the standards case relative to the base case. DOE calculated the NES by subtracting energy use under a standards scenario from energy use in a base-case scenario.

Unit energy savings for each equipment class are the same weighted-average values as calculated in the LCC and PBP spreadsheet. To estimate the total energy savings for each TSL, DOE first calculated the national site energy consumption (i.e., the energy directly consumed by the units of equipment in operation) for PTACs or PTHPs for each year, beginning with the expected effective date of the standards (2012), for the base case forecast and the standards case forecast. Second, DOE determined the annual site energy savings, consisting of the difference in site energy consumption between the base case and the standards case. Third, DOE converted the annual site energy savings into the annual amount of energy saved at the source of electricity generation (the source energy), using a site-to-source conversion factor. Finally, DOE summed the annual source energy savings from 2012 to 2042 to calculate the total NES for that period. DOE performed these calculations for each TSL considered in this rulemaking.

To estimate NPV, DOE calculated the net impact as the difference between total operating cost savings (including electricity, repair, and maintenance cost savings) and increases in total installed costs (which consists of MSP, sales taxes, distribution chain markups, and installation cost). DOE calculated the NPV of each TSL over the life of the equipment, using the following three steps. First, DOE determined the difference between the equipment costs under the TSL case and the base case in order to obtain the net equipment cost increase resulting from the TSL. Second, DOE determined the difference between the base case operating costs and the TSL operating costs, in order to obtain the net operating cost savings from the TSL. Third, DOE determined the difference between the net operating cost savings and the net equipment cost increase in order to obtain the net savings (or expense) for each year. DOE then discounted the annual net savings (or expenses) to the year 2008 for PTACs and PTHPs bought on or after 2012 and summed the discounted values to provide the NPV of a TSL. An NPV greater than zero shows net savings (i.e., the TSL would reduce customer expenditures relative to the base case in present value terms). An NPV that is less than zero indicates that the TSL would result in a net increase in customer expenditures in present value terms.

Although voluntary energy efficiency programs may increase the share of energy-efficient equipment prior to the implementation date of any new or amended energy conservation standards, DOE was not able to obtain information that quantified how such programs affect equipment efficiencies on a national basis. Consequently, DOE did not explicitly incorporate the impact of market-based voluntary energy efficiency programs into the shipment forecasts detailed in Chapter 10 of this TSD.

11.1.2 NES and NPV Input Summary

The important inputs of national energy consumption for each PTAC and PTHP equipment class include: 1) shipments of each equipment class, 2) existing stock of each equipment class 3) national average energy consumption for each equipment class, and 4) site-to-source conversion factor to translate electricity consumption at the site of use into the amount of energy that must be generated at the power plant (source) and then transmitted to the site where it is consumed. Chapter 10 provides a detailed description of the shipments model that DOE used to forecast future purchases of PTAC and PTHP equipment. Table 11.1.1 summarizes the inputs to the NES spreadsheet model. For each input a brief description of the data source is given.

Table 11.1.1 Summary of NES and NPV Model Inputs

Inputs	Description
Shipments	Annual shipments from shipments model (see Chapter 10 of the TSD).
Effective Date of Standard	September 2012
Base Case Efficiencies	Distribution of base-case shipments by efficiency level.
Standard Case Efficiencies	Distribution of shipments by efficiency level for each standards case. Standards case annual shipment-weighted market shares remain constant for base case and each standard level for all efficiencies above the TSL. All other shipments are at the TSL efficiency
Annual Energy Use per Unit	Annual national weighted-average values are a function of efficiency level (Chapter 7 of the TSD).
Total Installed Cost per Unit	Annual weighted-average values are a function of efficiency level (Chapter 8 of the TSD).
Repair Cost per Unit	Annual weighted-average values increase with manufacturer's cost level (Chapter 8 of the TSD).
Maintenance Cost per Unit	Annual weighted-average value equals $50 (Chapter 8 of the TSD)
Escalation of Electricity Prices	2007 EIA AEO forecasts (to 2030) and extrapolation for beyond 2030 (Chapter 8 of the TSD).
Electricity Site-to-Source Conversion Factor	Conversion factor varies yearly and is generated by EIA's NEMS* model. Includes the impact of electric generation, transmission, and distribution losses.
Discount Rate	3 and 7 percent real.
Present Year	Future costs are discounted to year 2008.

* Chapter 14 on the utility impact analysis provides more detail on NEMS.

11.2 NATIONAL ENERGY SAVINGS

11.2.1 NES Definition

DOE calculates annual national energy savings for a given year (t) as the difference between two scenarios: a base case (without new or amended standards) and a standards case (with new or amended standards). Positive values of NES correspond to net annual energy savings, i.e., annual national energy consumption (AEC) with standards is less than AEC in the base case.

$$NES_t = AEC_{base} - AEC_{standard} \qquad \textbf{Eq. 11.1}$$

Cumulative energy savings are the sum over a defined time period from the implementation of a standard forward (from 2012 to 2042) of the annual national energy savings.

$$NES_{cum} = \sum_t NES_t \qquad \textbf{Eq. 11.2}$$

DOE calculated the AEC by multiplying the number or stock of units of PTAC and PTHP equipment (by vintage) by the unit energy consumption (also by vintage) as shown by the following equation:

$$AEC = \sum_v (STOCK_V \text{ x } UEC_V \text{ x } src\_conv_t) \qquad \textbf{Eq. 11.3}$$

For the above expressions, DOE defined the following quantities:

AEC = Annual national energy consumption each year in quads, summed over vintages of PTAC and PTHP equipment stock, $STOCK_V$,

NES = Annual national energy savings (in quads),

$STOCK_V$ = Stock of PTAC and PTHP equipment (millions of units) of vintage V surviving in the year for which DOE calculated annual energy consumption,

Vintages range from 1 year to approximately 20 years, a function of an assumed 10-year average lifetime for PTAC and PTHP equipment,

UEC_V = Annual unit energy consumption in kilowatt hours (kWh) of vintage V,

src_conv_t = Time-dependent conversion factor to convert from site energy (kWh) to source energy (quads) (Btu/kWh),

V = Year in which the PTAC or PTHP equipment was purchased as a new unit,

t = Year in the forecast (e.g., 2012 to 2042).

The stock of PTAC and PTHP equipment is dependent on annual shipments and the lifetime of the equipment. DOE believes that the shipment projections under the standards cases could be lower than those in the base case projection, because the higher installed costs would cause some customers to forego new equipment purchases. However, DOE has no sufficient information that would allow a calculation of this effect. For the notice of proposed rulemaking (NOPR), DOE estimated the total shipments assuming that the projections are the same in both the base case and standards cases.

11.2.2 NES Inputs

The inputs for the determination of NES are listed below:

- Annual unit energy consumption (kWh/year) (section 11.2.2.1)
- Shipments (section 11.2.2.2)
- Equipment stock (section 11.2.2.3)
- National annual energy consumption (section 11.2.2.4)
- Site-to-source conversion factor (section 11.2.2.5)

11.2.2.1 Annual Unit Energy Consumption

The annual unit energy consumption (UEC) is the site energy consumed by a PTAC or PTHP unit per year. The UEC is directly tied to the efficiency of the unit. Thus, knowing the efficiency of a PTAC or PTHP unit determines the corresponding annual energy consumption. DOE estimated the annual unit energy consumption for each of PTAC and PTHP equipment classes, as discussed in the energy use characterization analysis in Chapter 7. As described below, DOE determined annual forecasted shipment-weighted average equipment efficiencies that, in turn, enabled a determination of shipment-weighted annual energy consumption values.

First, DOE converted the 2005 PTAC and PTHP equipment shipments by equipment class into market shares by equipment class, then adapted an economic model that employed a cost-based method used in the Energy Information Administration (EIA)'s National Energy Modeling System (NEMS) to estimate market shares for each equipment class by TSL.[1] Then, from those market shares and projections of shipments by equipment class, DOE extrapolated future trends of PTAC and PTHP equipment efficiency both for a base case scenario (i.e., without new standards) and various standards case scenarios (i.e., with new standards). The difference in equipment efficiency between the base case and standards cases was the basis for determining the reduction in per-unit annual energy consumption that could result from new standards.

The market share for each equipment class by TSL is defined as *EFF_Level_Share(i,y)*, for each equipment class *y* at TSL *i*. Because the average lifetime of each equipment class is presumed to be the same, and because DOE had no information regarding future changes in market shares between equipment classes, DOE assumed the market share for a particular equipment class to be constant over time. DOE calculated the *EFF_Level_Share(i,y)* for each TSL *i* using the following formula, based on the relative annualized cost of each TSL.

$$EFF\_Level\_Share(i,y) = \sum_{j=1}^{m} b_j \times \frac{IC_{(i,y)} \times \left(\frac{r_j}{1-(1+r_j)^{-n}} + OC_{(i.y)} \right)^{-v}}{\sum_{i=1}^{k} IC_{(i,y)} \times \left(\frac{r_j}{1-(1+r_j)^{-n}} + OC_{(i.y)} \right)^{-v}} \qquad \textbf{Eq. 11.4}$$

where

EFF_Level_Share(i,y) = the market share of equipment class *y* at TSL *i*,

IC(i, y) = installed costs of equipment class y at TSL *i*, *i*=1 to *k*.

OC(i,y) = annual operating cost (maintenance, repair, and energy cost) of equipment class *y* at TSL *i,*

r_j = private, risk-adjusted discount rate for risk class *j*. Derived by adding a "time preference premium" to the risk-free real rate of return in the marketplace (4.39% long-term Treasury bond rate, minus the estimated long-term inflation rate of 2.2% = 2.19%)
b_j = market share of equipment users with risk class *j*, *j* =1 to *m*,

v = risk penalty factor (also known as a measure of market heterogeneity)

n = equipment lifetime

The components for *IC* and *OC* came from the same inputs as the life-cycle cost analysis (see Chapter 8, life-cycle cost and payback period analysis). The annualization factor $(r_j/(1-(1+r_j)^{-n})$ converts installed cost into its annualized equivalent, so that market shares are based on the relative annualized costs of each TSL, with (generally) higher annualized costs of higher TSLs leading to lower relative market shares. This is consistent with the approaches used in the EIA's NEMS[1] and in Canada's CIMS model[2a]. The calibration constants are the private risk-based discount rates by risk class r_j, taken from the NEMS commercial model as shown in Table 11.2.1, the default value of v = 10, taken from the CIMS model, and the equipment lifetime of 10 years.

Table 11.2.1 Risk Premiums by Risk Class (j) in the NEMS Commercial Model

Percentage of Users in Class	Time Preference Premium	Implied Real Discount Rate
1%	0.0%	2.14%
2%	13.6%	15.45%
10%	19.9%	21.61%
15%	30.9%	32.38%
20%	55.4%	56.35%
25%	152.9%	151.75%
27%	1000.0%	980.62%
100%		

Source: EIA's NEMS Commercial Model

Table 11.2.2 and Table 11.2.3 provide estimated base case shipment-weighted market shares for each of the equipment classes of PTACs and PTHPs, respectively, proposed in this rulemaking.

[a] The CIMS Model was originally known as the Canadian Integrated Modeling System, but as the model is now being applied to other countries, the acronym is now used as its proper name.

Table 11.2.2 Shipment-Weighted Market Shares by Efficiency Level for PTACs, Base Case

Equipment Class	Cooling Capacity	Shipment-Weighted Market Shares by Efficiency Level*					
		Baseline (ASHRAE 90.1-1999)	TSL 1,2,4	TSL 3	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	≤ 10,000 Btu/h	19.2%	18.0%	17.2%	16.4%	15.6%	13.5%
	> 10,000 Btu/h	19.9%	18.5%	17.5%	16.5%	15.5%	12.1%
Non-Standard Size PTAC	All Capacity	19.8%	18.6%	17.8%	16.9%	14.4%	12.5%

* Shares may not add to 100% exactly due to rounding.

Table 11.2.3 Shipment-Weighted Market Shares by Efficiency Level for PTHPs, Base Case

Equipment Class	Cooling Capacity	Shipment-Weighted Market Shares by Efficiency Level*					
		Baseline (ASHRAE 90.1-1999)	TSL 1	TSL 2,3	TSL4,5	TSL 6	TSL 7 (Max Tech)
Standard Size PTHP	≤ 10,000 Btu/h	18.8%	17.5%	17.0%	16.5%	15.8%	14.4%
	> 10,000 Btu/h	19.8%	18.1%	17.5%	16.7%	15.8%	12.1%
Non-Standard Size PTHP	All Capacity	19.1%	18.5%	17.8%	17.2%	14.9%	12.4%

* Shares may not add to 100% exactly due to rounding.

To project changes in weighted average TSLs as amended standards above baseline efficiency level (i.e., ASHRAE/IESNA Standard 90.1-1999)[b] are introduced, DOE assumed that market shares above the minimum permitted efficiency level would be reassigned to the new minimum level (i.e., the amended standard). This is called a "roll-up" scenario. For example, if TSL 3 was imposed as the new standard in 2012 on standard size PTAC with a cooling capacity of 9,000 British thermal units per hours (Btu/h) equipment, then the market shares for baseline efficiency level, TSL 1 and TSL 2 would be assigned to TSL 3, which would result in a total market share of 54.4 percent, i.e., by adding 19.2 percent, 18.0 percent, and 17.2 percent from the first three columns of the first row in Table 11.2.2, beginning in 2012. The market shares for TSL 5, 6 and 7 would not be affected because the market already has a choice of that equipment with TSL 3 also available. DOE, thus, assumed that the new standard would not affect the relative attractiveness of equipment with efficiencies higher than the standard.

As stated earlier, annual energy consumption values are tied directly to the efficiency of the equipment. Table 11.2.4 provides weighted-average annual energy consumption values for specific TSLs for all six representative cooling capacities of PTACs and PTHPs.

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[b] ASHRAE/IESNA Standard 90.1-1999 stands for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) and the Illuminating Engineering Society of North America (IESNA) Standard 90.1-1999, *"Energy Standard for Buildings Except Low-Rise Residential Buildings" (ASHRAE/IESNA Standard 90.1-1999).*

Table 11.2.4 Annual Unit Energy Consumption by Efficiency Level

Equipment Class	Representative Cooling Capacity	Annual unit energy consumption (kWh/year/unit) Baseline (ASHRAE 90.1-1999)	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	9,000 Btu/h	1,045	1,026	1,026	1,013	1,026	1,001	990	962
	12,000 Btu/h	1,317	1,294	1,294	1,279	1,294	1,264	1,251	1,206
Standard Size PTHP	9,000 Btu/h	2,063	2,013	1,984	1,984	1,957	1,957	1,945	1,890
	12,000 Btu/h	2,467	2,406	2,370	2,370	2,356	2,356	2,343	2,250
Non-Standard Size PTAC	11,000 Btu/h	1,658	1,584	1,584	1,559	1,584	1,536	1,487	1,456
Non-Standard Size PTHP	11,000 Btu/h	2,661	2,533	2,508	2,508	2,465	2,465	2,416	2,373

For the annual shipment-weighted efficiency levels specified in the base case and standards case efficiency scenarios, DOE calculated the shipment-weighted UEC values in Table 11.2.5. For each equipment class, the value shown for a given TSL is the efficiency weighted average annual unit energy consumption, after taking into account the non-availability of equipment at the TSL shown below.

Table 11.2.5 Shipment-Weighted Average Annual Unit Energy Consumption by Efficiency Level

Equipment Class	Representative Cooling Capacity	Shipment-weighted average annual unit energy consumption (kWh/year/unit) TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	9,000 Btu/h	1,005	1,005	1,001	1,005	994	986	962
	12,000 Btu/h	1,269	1,269	1,263	1,269	1,255	1,245	1,206
Standard Size PTHP	9,000 Btu/h	1,971	1,960	1,960	1,946	1,946	1,938	1,890
	12,000 Btu/h	2,362	2,349	2,349	2,341	2,341	2,331	2,250
Non-Standard Size PTAC	11,000 Btu/h	1,541	1,541	1,532	1,541	1,519	1,483	1,456
Non-Standard Size PTHP	11,000 Btu/h	2,479	2,470	2,470	2,446	2,446	2,411	2,373

11.2.2.2 Shipments

DOE forecasted shipments for the base case and all standards cases (see Chapter 10, shipment analysis).

11.2.2.3 Equipment Stock

In a given year, PTAC and PTHP equipment stock is the total units of PTAC and PTHP equipment shipped from earlier years which survive in that year. The NES spreadsheet model keeps track of the total number of PTAC and PTHP units shipped each year. For purposes of the NES and NPV analyses, DOE assumed that approximately 10 percent of the existing PTAC and PTHP units are retired in each year (based on a 10-year average lifetime) and that for units shipped in 2042, any units still remaining at the end of 2052 will be replaced. DOE assumed that the existing PTAC and PTHP units are retired by following a Weibull distribution with an average lifetime of 10 years. The Weibull distribution shows that approximately 8 percent of the existing PTAC and PTHP units are retired from 2012 to 2019 (i.e. by year 7), then tail off gradually to less than one percent per year by year 20. Retired units are replaced until 2042. For units shipped in 2042, any units still remaining at the end of 2062 are replaced.

11.2.2.4 National Annual Energy Consumption

The national AEC is the product of the annual UEC and the stocks of PTAC and PTHP units of each vintage. This approach accounts for differences in unit energy consumption from year to year. Equation 11.3 above was used for determining the national annual energy consumption of PTAC and PTHP equipment.

In determining AEC, DOE initially calculated the annual energy consumption at the site (i.e., electricity in kWh consumed by the PTAC and PTHP unit). DOE then calculated primary energy consumption converted from site energy consumption by applying a marginal site-to-source conversion factor to account for losses associated with the generation, transmission, and distribution of electricity.

11.2.2.5 Site-to-Source Conversion Factor

The site-to-source conversion factor is the multiplier used for converting site energy consumption, expressed in kWh, into primary or source energy consumption, expressed in quads. The site-to-source conversion factor accounts for losses in electricity generation, transmission, and distribution. DOE used annual site-to-source marginal conversion factors based on a detailed analysis contained in appendix H. Theses factors take into account the fact that energy savings that would occur as a result of adopting more efficient equipment standard for PTACs and PTHPs would be most likely to reduce demand for energy from power plants used for peaking power and load following, and which have heat rates lower than the U.S. average values. As shown in Table 11.2.6, the conversion factors vary over time, due to projected changes in electricity generation sources (i.e., the power plant types projected to provide electricity to the country). Detailed discussion on calculations of marginal site-to-source conversion factors can be found in appendix H.

Table 11.2.6 Marginal Site-to-Source Conversion Factors (Btu/kWh)

Year	PTACs	Year	PTHPs
2012	13,661	2012	14,213
2013	13,661	2013	14,213
2014	12,840	2014	13,391
2015	13,353	2015	13,050
2016	12,730	2016	11,716
2017	11,298	2017	10,190
2018	10,276	2018	9,366
2019	9,877	2019	9,641
2020	9,513	2020	8,975
2021	8,892	2021	8,596
2022	8,502	2022	9,212
2023	8,371	2023	9,567
2024	8,344	2024	9,723
2025	7,996	2025	9,141
2026	7,576	2026	8,618
2027	7,023	2027	8,146
2028	6,381	2028	7,665
2029	6,079	2029	7,442
2030-2042	6,079	2030-2042	7,442

11.3 NET PRESENT VALUE

11.3.1 Net Present Value Definition

The NPV is the value in the present of a time series of costs and savings. The NPV is given by the equation:

$$NPV = PVS - PVC \qquad \textbf{Eq. 11.5}$$

where

PVS = present value of operating cost savings (including energy, repair, and maintenance costs),
PVC = present value of increased total installed costs (including equipment and installation).

The *PVS* and *PVC* are determined according to the following expressions:

$$PVS = \sum_t OCS_t \text{ x } DF_t \qquad \textbf{Eq. 11.6}$$

$$PVC = \sum_t TIC_t \text{ x } DF_t \qquad \textbf{Eq. 11.7}$$

where:

OCS = total annual operating cost savings,
TIC = total annual installed cost increases,
DF = discount factor,
t = year (*PVS* is summed over 2012-2062, and *PVC* is summed over 2012-2062).

DOE determined the contribution to *PVC* for each year, from the effective date of the amended standard (year 2012) to the year 2062, discounted for the NOPR analysis, to the year 2008. All dollar values are reported in constant 2006 dollars. The contribution to *PVS* was calculated for each year, from the effective date of the same amended standard (year 2012) to the year when units purchased in 2042 retire (assumed to be 2062). DOE calculated costs and savings as the difference between a standards case (i.e., with an amended standard) and a base case (i.e., without new standards). DOE calculated a discount factor from the discount rate and the number of years between the "present" (i.e., year to which the sum is being discounted) and the year in which the costs and savings occur. The net present value is the sum over time of the discounted net savings, which is equivalent to the approach shown in Eq. 11.5 to Eq. 11.7.

11.3.2 Net Present Value Inputs

The inputs to the NPV calculation are listed below:

- Total Annual Installed Cost (section 11.3.2.1)
- Total Annual Operating Cost Savings (section 11.3.2.2)
- Discount Factor (section 11.3.2.3)
- Present Value of Costs (section 11.3.2.4)
- Present Value of Savings (section 11.3.2.5)

11.3.2.1 Total Annual Installed Cost

The increase in the total annual installed cost is equal to the annual change in the per-unit total installed cost (difference between base case and standards case) multiplied by the shipments forecasted in the standard case. The total installed cost includes both the equipment cost and the installation price. DOE based average equipment costs on average manufacturer selling prices multiplied by average overall markup values (see Chapter 8, life-cycle cost and payback period analyses). DOE based average installation prices on nationally representative values for each equipment class (see Chapter 8). Table 11.3.1 shows the resulting average total installed costs per unit for each of the equipment classes of PTAC and PTHP equipment by TSLs.

Table 11.3.1 Average Total Installed Cost per Unit by Trial Standard Level (2006$)

Equipment Class	Representative Cooling Capacity	Average Total Installed Cost per Unit (2006$)							
		Baseline (ASHRAE 90.1-1999)	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	9,000 Btu/h	$1,118	$1,128	$1,128	$1,136	$1,128	$1,144	$1,152	$1,175
	12,000 Btu/h	$1,326	$1,340	$1,340	$1,350	$1,340	$1,361	$1,373	$1,420
Standard Size PTHP	9,000 Btu/h	$1,234	$1,251	$1,259	$1,259	$1,267	$1,267	$1,275	$1,298
	12,000 Btu/h	$1,439	$1,462	$1,472	$1,472	$1,483	$1,483	$1,495	$1,557
Non-Standard Size PTAC	11,000 Btu/h	$1,441	$1,461	$1,461	$1,471	$1,461	$1,483	$1,518	$1,548
Non-Standard Size PTHP	11,000 Btu/h	$1,563	$1,584	$1,595	$1,595	$1,607	$1,607	$1,641	$1,641

DOE developed base case and standards case energy efficiency scenarios as discussed in section 11.2.2.1. For both the base case and standards case energy efficiency scenarios, DOE calculated annual shipment-weighted average efficiencies. Associated with each annual shipment-weighted average efficiency value, DOE assigned a total installed cost, based on shipment-weighted total installed cost for all TSLs. DOE based the relationship between efficiency and total installed cost for each PTAC and PTHP equipment class on the data in Table 11.3.2. As shown in Table 11.3.2, DOE estimated the shipments-weighted installed cost. DOE determined forecasted average shipments-weighted total installed costs based on the annual shipments by TSL.

Table 11.3.2 Shipment-Weighted Average Total Installed Cost per Unit by Trial Standard Level (2006$)

Equipment Class	Representative Cooling Capacity	Shipment-Weighted Average Total Installed Cost per Unit (2006$)						
		TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	9,000 Btu/h	$1,142	$1,142	$1,145	$1,142	$1,149	$1,155	$1,175
	12,000 Btu/h	$1,360	$1,360	$1,364	$1,360	$1,370	$1,379	$1,420
Standard Size PTHP	9,000 Btu/h	$1,266	$1,268	$1,268	$1,273	$1,273	$1,278	$1,298
	12,000 Btu/h	$1,484	$1,488	$1,488	$1,494	$1,494	$1,503	$1,557
Non-Standard Size PTAC	11,000 Btu/h	$1,485	$1,485	$1,489	$1,485	$1,496	$1,522	$1,548
Non-Standard Size PTHP	11,000 Btu/h	$1,606	$1,610	$1,610	$1,616	$1,616	$1,641	$1,641

11.3.2.2 Total Annual Operating Cost Savings

The annual operating cost savings to the Nation are equal to the change in the annual operating costs (difference between base case and standards case) per unit multiplied by the shipments forecasted in the standards case. The annual operating cost includes electricity, repair, and maintenance costs.

Annual Electricity Cost Savings. As described in Chapter 8, DOE calculated annual electricity costs based on average State-level commercial electricity prices. To calculate annual energy cost savings for a particular equipment class in a given year, DOE first calculated the annual energy costs in each forecast year at each TSL from Table 11.2.5 multiplied by 1) the units of surviving equipment stock in the equipment class in each year, and then 2) by the sales-weighted national average electricity prices for the four business types in Chapter 8. To determine energy cost savings, the national energy costs at each TSL were then subtracted from the national energy costs at the baseline level.

Annual Repair Costs. DOE based average annual repair costs on the value of the PTAC and PTHP equipment (see Chapter 8). Table 11.3.3 shows the average per-unit repair costs for each of the equipment classes of PTACs and PTHPs. The NES spreadsheet provides the capability to allow repair costs to differ by the price of the PTAC and PTHP equipment, and therefore by TSL. For the purposes of this NOPR analysis, DOE assumed the repair costs to increase in each equipment class as the manufacturer selling price increases, as shown in Table 11.3.3.

Table 11.3.3 Average Annual Repair Cost per Unit (2006$)

Equipment Class	Representative Cooling Capacity	Average Annual Repair Cost per Unit (2006$)							
		Baseline (ASHRAE 90.1-1999)	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7 (Max Tech)
Standard Size PTAC	9,000 Btu/h	$15.25	$15.52	$15.52	$15.71	$15.52	$15.92	$16.13	$16.70
	12,000 Btu/h	$15.25	$15.56	$15.56	$15.78	$15.56	$16.02	$16.28	$17.29
Standard Size PTHP	9,000 Btu/h	$15.25	$15.64	$15.81	$15.81	$15.99	$15.99	$16.18	$16.69
	12,000 Btu/h	$15.25	$15.70	$15.90	$15.90	$16.12	$16.12	$16.35	$17.56
Non-Standard Size PTAC	11,000 Btu/h	$15.25	$15.63	$15.63	$15.84	$15.63	$16.07	$16.74	$17.32
Non-Standard Size PTHP	11,000 Btu/h	$15.25	$15.63	$15.81	$15.81	$16.02	$16.02	$16.63	$17.39

Annual Maintenance Costs. DOE was unable to locate any data on annual preventive maintenance cost (see Chapter 8), but annual maintenance is believed to be a relatively simple and inexpensive process for PTAC and PTHP equipment. An annual value of $50 per unit was assigned to all equipment. Table 11.3.4 shows the resulting annual maintenance costs per unit, which does not vary with TSL.

Table 11.3.4 Average Annual Maintenance Cost per Unit (2006$)

Equipment Classes	Cost per Unit ($2006)
Standard Size PTAC	$50
Standard Size PTHP	$50
Non-Standard Size PTAC	$50
Non-Standard Size PTHP	$50

11.3.2.3 Discount Factor

DOE determined present value of monetary values in future years using the discount factor. The discount factor *DF* is described by the equation:

$$DF = \frac{1}{(1+r)^{t-tp}} \qquad \textbf{Eq. 11.8}$$

where:

r = discount rate,
t = year the monetary value is accrued,
t_P = year in which the present value is being determined.

DOE estimated national impacts with both a three percent and a seven percent real (adjusted for inflation) discount rate as the average real rate of return on private investment in the U.S. economy. These discount rates are used in accordance with the Office of Management and

Budget (OMB)'s guidance to Federal agencies on the development of regulatory analysis (OMB Circular A-4, September 17, 2003), and section E., "Identifying and Measuring Benefits and Costs," therein. DOE defined the present year as 2008 for the NOPR analysis.

11.3.2.4 Present Value of Costs

The present value of increased installed costs is the annual installed cost increase in each year (i.e., the difference between the standards case and base case), discounted to the present, and summed for the time period over which DOE is considering the installation of PTAC and PTHP equipment (i.e., from the effective date of standards, 2012, to the year 2042, the last year in which installations occur).

The increase in total installed cost refers to both equipment cost and installation cost associated with the higher energy efficiency of PTAC and PTHP units purchased in the standards case compared to the base case. DOE calculated the difference in installed cost as the difference in between total installed costs with and without the standard case scenarios. Total installed cost in each case was calculated as the unit installed costs of equipment at each TSL, times the number of units of each TSL shipped in each year with and without the standard.

11.3.2.5 Present Value of Savings

The present value of operating cost savings is the annual operating cost savings (i.e., the difference between the base case and standards case) discounted to the year 2008, the year of the publication of the NOPR for this rulemaking, and summed over the period from the effective date, 2012, to the time when the last unit installed in 2042 is retired from service (assumed to be 2062). Savings are decreases in operating costs (including electricity, repair, and maintenance costs) associated with the higher energy efficiency of PTAC and PTHP units purchased in the standards case compared to the base case. Total annual operating cost savings is the savings per unit multiplied by the number of units of each vintage surviving in a particular year. Equipment consumes energy over its entire lifetime, and for units purchased in 2042, the PVS includes the cost of energy consumed until the unit is retired from service.

11.4 NES AND NPV RESULTS

The NES spreadsheet model provides estimates of the NES and NPV due to various trial standard levels. The inputs to the NES spreadsheet have been discussed earlier in sections 11.2.2 (NES Inputs) and 11.3.2 (NPV Inputs).

11.4.1 National Energy Savings Results

The following section provides NES results for each energy consumption level considered for the four equipment classes of packaged terminal air conditioner and heat pumps. Results are cumulative to 2042 and are shown as primary energy savings in quads. Inputs to the NES spreadsheet model are based on weighted-average values, yielding results which are discrete point values, rather than a distribution of values as in the life-cycle cost (LCC) analysis.

Table 11.4.1 shows the NES results for the trial standard levels analyzed for each equipment class of PTACs and PTHPs. DOE based all the results on electricity price forecasts from the 2007 EIA *Annual Energy Outlook* (AEO2007) Reference Case. In addition, Table 11.4.2 and Table 11.4.3 also show the magnitude of the energy savings if the savings are discounted at rates of 7 percent and 3 percent, respectively.

DOE reports both undiscounted and discounted values of energy savings. There is evidence that each TSL that is more stringent than the corresponding level in ASHRAE/IESNA Standard 90.1-1999 results in additional energy savings, ranging from 0.008 quads to 0.086 quads for TSLs 1 through 7.

Table 11.4.1 Cumulative National Energy Savings for PTACs and PTHPs

	Cumulative Energy Savings (2012-2042) (quads)						
Equipment Class	**TSL 1**	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**	**TSL 6**	**TSL 7**
Standard Size PTAC	0.002	0.002	0.005	0.002	0.009	0.013	0.029
Standard Size PTHP	0.005	0.010	0.010	0.015	0.015	0.018	0.047
Non-Standard Size PTAC	0.001	0.001	0.001	0.001	0.002	0.003	0.004
Non-Standard Size PTHP	0.001	0.001	0.001	0.002	0.002	0.004	0.005
Total	0.008	0.014	0.017	0.019	0.027	0.038	0.086

Table 11.4.2 Cumulative National Energy Savings for PTACs and PTHPs Based on Seven-Percent Discount Rate

	Cumulative Energy Savings (2012-2042) (quads)						
Equipment Class	**TSL 1**	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**	**TSL 6**	**TSL 7**
Standard Size PTAC	0.001	0.001	0.001	0.001	0.002	0.004	0.008
Standard Size PTHP	0.001	0.003	0.003	0.004	0.004	0.005	0.012
Non-Standard Size PTAC	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Non-Standard Size PTHP	0.000	0.000	0.000	0.001	0.001	0.001	0.001
Total	0.002	0.004	0.004	0.005	0.007	0.010	0.023

Table 11.4.3 Cumulative National Energy Savings for PTACs and PTHPs Based on Three-Percent Discount Rate

Equipment Class	Cumulative Energy Savings (2012-2042) (quads)						
	TSL 1	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**	**TSL 6**	**TSL 7**
Standard Size PTAC	0.001	0.001	0.003	0.001	0.005	0.007	0.016
Standard Size PTHP	0.003	0.005	0.005	0.008	0.008	0.010	0.025
Non-Standard Size PTAC	0.000	0.000	0.001	0.000	0.001	0.002	0.002
Non-Standard Size PTHP	0.000	0.001	0.001	0.001	0.001	0.002	0.003
Total	0.005	0.008	0.009	0.010	0.014	0.021	0.046

11.4.2 Annual Costs and Savings

As a prelude to providing the NPVs for each trial standard level in each equipment class, this section presents the annual equipment cost (or total installed cost) increases and annual operating cost savings at the national level.

Figure 11.4.1 shows the changes over time of the non-discounted annual equipment price increases and the non-discounted operating cost savings at TSL 1 for standard size PTAC with a cooling capacity of 9,000 Btu/h. The total net annual impact is the discounted value of the difference between annual equipment purchases and annual operating costs at a seven percent discount rate. Appendix G shows comparable figures for other TSLs and other equipment classes. The annual equipment price change is the increase in equipment price for equipment purchased each year over the period 2012–2042. The annual operating cost savings is the savings in operating costs for equipment purchased, and which have not been retired, for each year over the time period 2012-2062. DOE determined the annual costs and savings presented in each figure based on the AEO2007 Reference Case. The NPV is the difference between the cumulative annual discounted savings and the cumulative annual discounted costs.

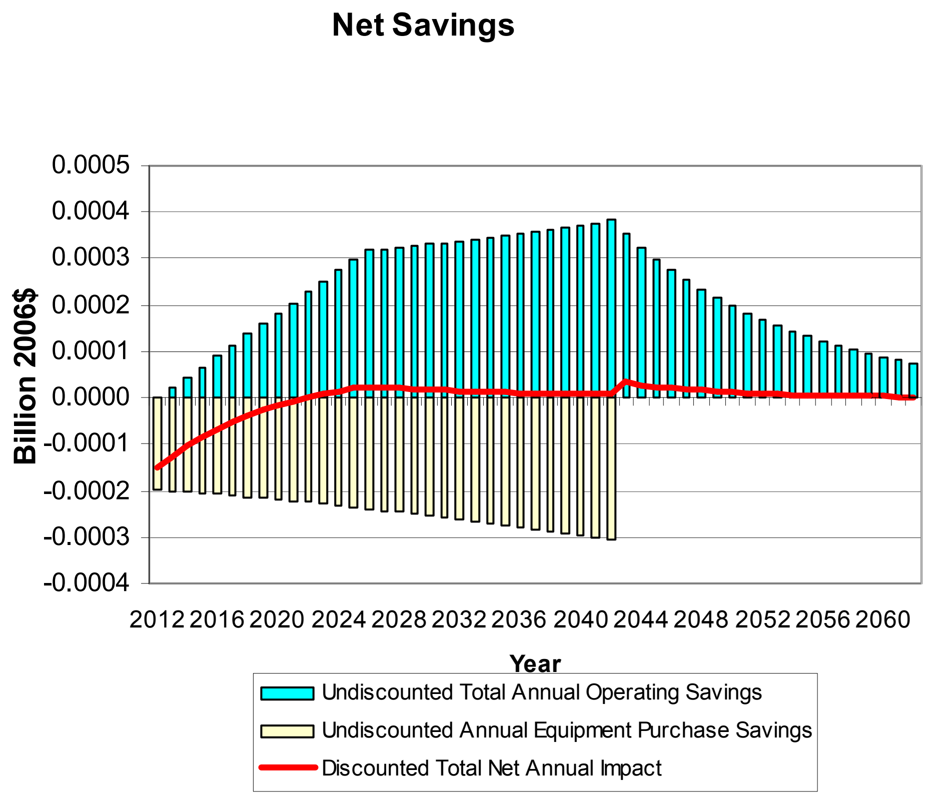

Figure 11.4.1 National Annual Costs and Savings for Standard Size PTAC, 9,000 Btu/h Cooling Capacity, TSL 1

Figure 11.4.1 initially shows smaller annual operating cost savings compared to the increased equipment price costs (shown on the figure as operating savings). For all trial standard levels, operating cost savings increase with time through 2042, as more and more equipment meeting the efficiency standard comprises the packaged terminal air conditioner and heat pump stock. The savings then decrease as the equipment retires and is not replaced.

11.4.3 Net Present Value Results

The following section provides NPV results for the trial standard levels considered for the equipment classes of PTACs and PTHPs. Results are cumulative and are shown as the discounted value of these savings in dollar terms. The present value of increased total installed costs is the total installed cost increase (i.e., the difference between the trial standard case and base case), discounted to 2008, and summed over the time period in which DOE evaluates the impact of standards (i.e., from the effective date of standards, 2012, to the year 2062).

Table 11.4.4 shows the NPV results for the TSLs considered for PTAC and PTHPs based upon a seven percent discount rate. DOE based all results on electricity price forecasts from the AEO2007 Reference Case. Detailed results showing the breakdown of the NPV into national equipment costs and national operating costs are provided in appendix G.

Table 11.4.4 Cumulative NPV Results Based on a Seven-Percent Discount Rate (Billion 2006$)

Equipment Class	Cumulative NPV – 7% Discount Rate (billion 2006$)*						
	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7
Standard Size PTAC	($0.001)	($0.001)	($0.003)	($0.001)	($0.009)	($0.018)	($0.068)
Standard Size PTHP	$0.004	$0.011	$0.011	$0.012	$0.012	$0.006	($0.005)
Non-Standard Size PTAC	$0.001	$0.001	$0.002	$0.001	$0.003	$0.003	$0.003
Non-Standard Size PTHP	$0.002	$0.003	$0.003	$0.004	$0.004	$0.005	$0.004
Total	$0.007	$0.014	$0.013	$0.017	$0.010	($0.004)	($0.067)

* Values in parentheses indicate negative NPV.

Table 11.4.5 provides the NPV results based on the three percent discount rate and electricity price forecasts from the AEO2007 Reference Case. As with the NPV results based upon a seven percent discount rate, detailed results showing the breakdown of the NPV into national equipment costs and national operating costs based upon a three percent discount rate are provided in appendix G.

Table 11.4.5 Cumulative NPV Results based on a Three-Percent Discount Rate (Billion 2006$)

Equipment Class	Cumulative NPV – 3% Discount Rate (billion 2006$)*						
	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7
Standard Size PTAC	$0.002	$0.002	$0.001	$0.002	($0.003)	($0.013)	($0.085)
Standard Size PTHP	$0.015	$0.036	$0.036	$0.044	$0.044	$0.037	$0.058
Non-Standard Size PTAC	$0.004	$0.004	$0.006	$0.004	$0.008	$0.013	$0.014
Non-Standard Size PTHP	$0.006	$0.007	$0.007	$0.012	$0.012	$0.015	$0.016
Total	$0.026	$0.049	$0.050	$0.061	$0.061	$0.052	$0.003

* Values in parentheses indicate negative NPV.

REFERENCES

1. Energy Information Administration (EIA). National Energy Modeling System Commercial Model (2004 Version).

2. ERG/MKJ. Energy Research Group & M.K. Jaccard & Associates. 2000. Integration of GHG Emissions Reduction Options using CIMS. <<http://www.emrg.sfu.ca/reports/Rollup.pdf>> (05 June 2001).